Spirit Creek Watershed Monitoring Committee

10-year report

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10 year report

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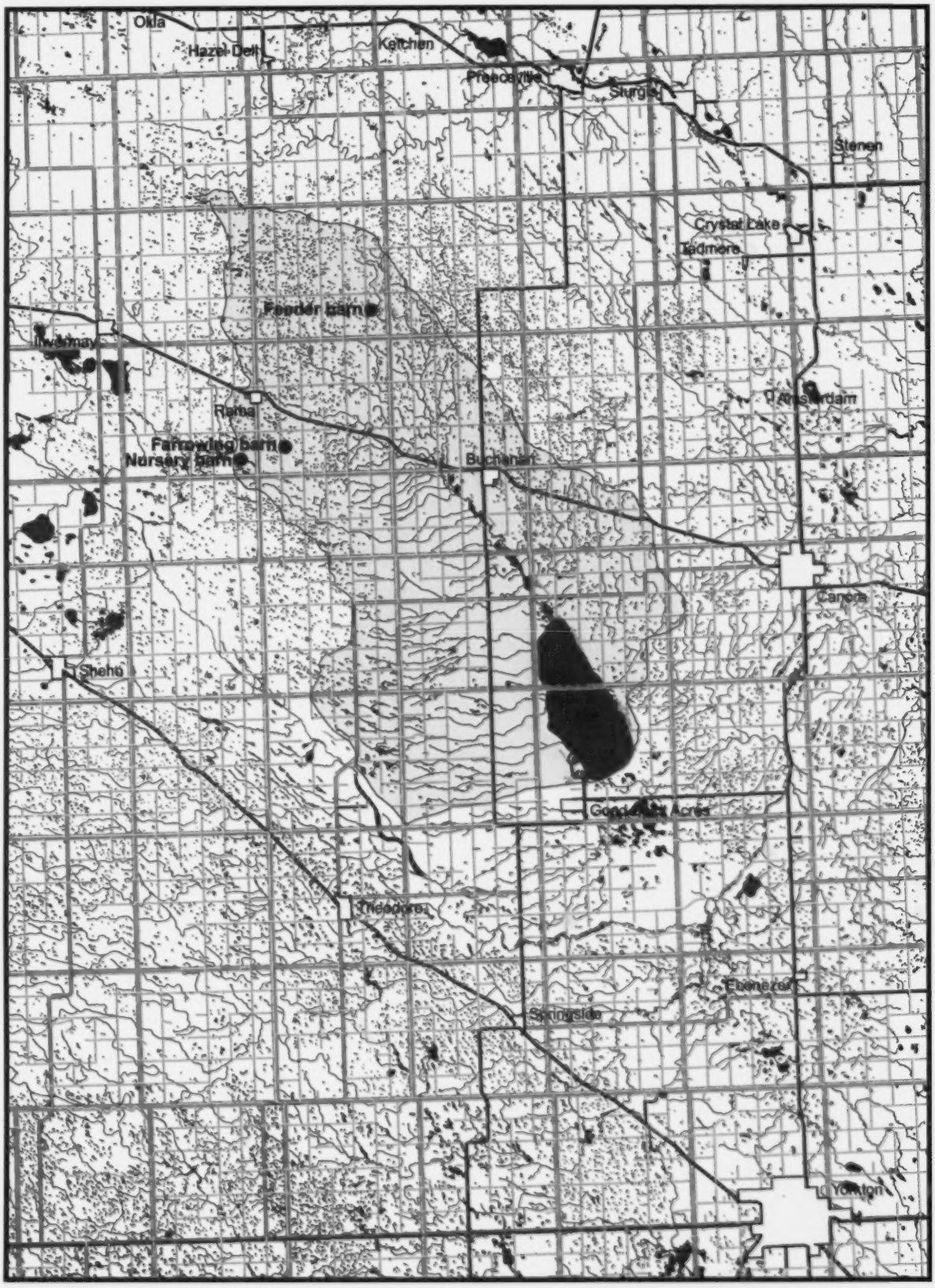
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Invermay
Rama
Amsterdam
Farrowing barn
Nursery barn
Buchanan
Canora
Sheho
Theodore
Ebenezer
Springside
Yorkton

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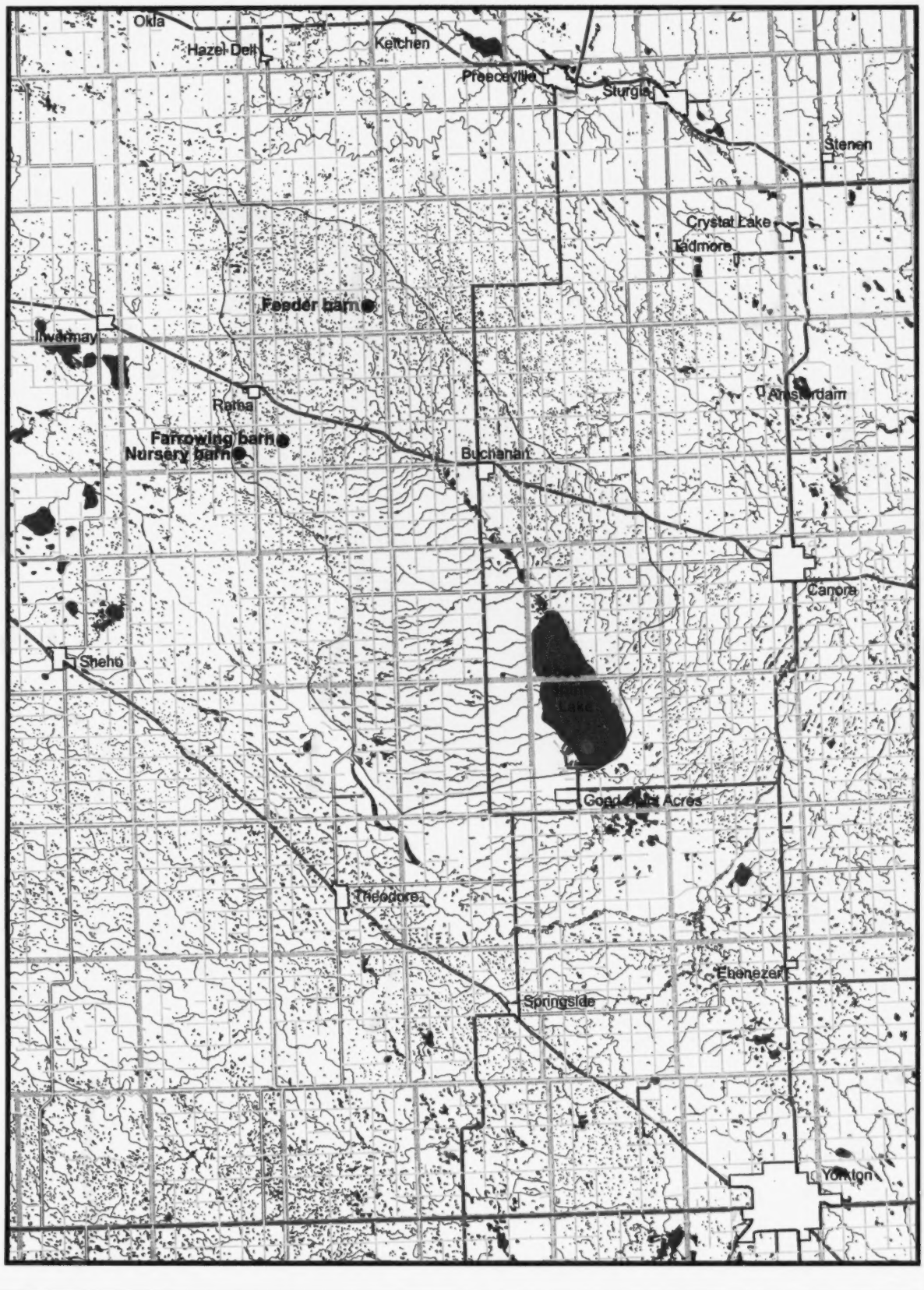
* Appendices A, B, C, D, E and F are part of the Five Year Report and available upon request or on the committee web site www.spiritcreek.ca.

This report is based on actual field sampling results carried out by/on behalf of the Spirit Creek Watershed Monitoring Committee.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LETTER OF TRANSMITTAL

February 7, 2011

The Honorable Bob Bjornerud,
Minister of Agriculture,
Room 334 Legislative Building,
Regina, Saskatchewan.
S4S OB3

Dear Minister Bjornerud:

We, the committee, are pleased to present you with the Ten Year Report (2000-2010) on the work completed by the Spirit Creek Watershed Monitoring Committee.

The report summarizes results, conclusions and recommendations over the period of activity since the Five Year Report was presented in 2006.

Respectfully submitted,

Eugene Wiwchar
Chairman
Spirit Creek Watershed Monitoring Committee

ACKNOWLEDGEMENTS

The Spirit Creek Watershed Monitoring Committee (SCWMC) would like to acknowledge and thank the committee members, past and present, who wrote reports and worked on the various subcommittees. Their commitment and devotion is commendable. Without it this project could not have succeeded.

Present Committee Members (2009-2012):

Eugene Wiwchar - chair
Ken Kowalchuk – vice chair
Adam Kosar – committee representative for water sampling & soil sampling activities

The SCWMC would like to acknowledge and thank the following individuals who provided expertise in contractual services over the last five years:

Mr. Keith Head - agrologist with Head and Associates Ltd. Mr. Head continues to coordinate and report on the soil monitoring project.

Mr. Dick DeRyk - Uncommon Sense. Developed and continues to maintain the website.

The SCWMC appreciates participation from the following groups:

Saskatchewan Ministry of Agriculture;

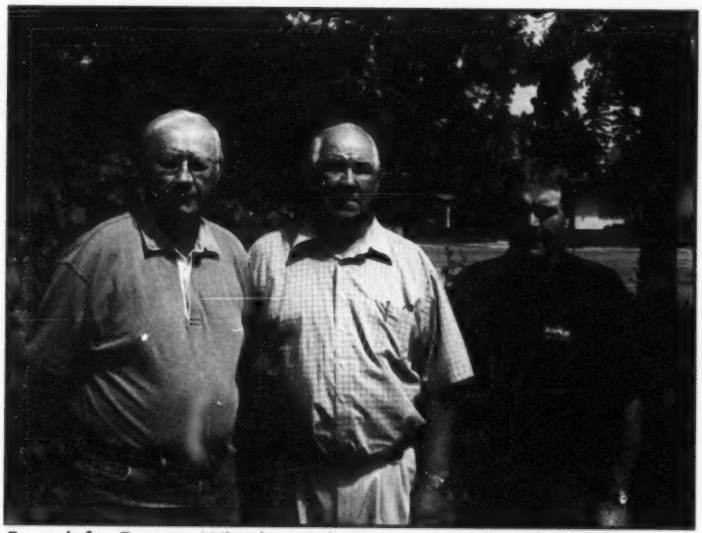
Saskatchewan Watershed Authority;

Saskatchewan Ministry of Environment;

Big Sky Farms Inc. - Ernie Patrick, Gary Sleeva, Duane Karcha;

Sask Pork - Harvey Wagner;

Residents of the Village of Rama and surrounding area.



From left: Eugene Wiwchar, Adam Kosar and Ken Kowalchuk.

EXECUTIVE SUMMARY

The Spirit Creek Watershed Monitoring Committee (SCWMC) was formed in 2000 as a response to proposed hog barn development in the Assiniboine River Watershed. Many concerns were voiced in the area regarding the potential environmental impact of the project. The development of the committee was the first of its kind in Canada to address local concerns The committee worked in cooperation with Big Sky Farms and various levels of government. The committee was given authorization to contract consulting services at their discretion.

The SCWMC mandate is to direct and communicate the monitoring of three hog barn sites to ensure the sustainability of the environment in the Spirit Creek Watershed. As a result of this mandate, the SCWMC is able to collect and present to the public current, site-specific information regarding the environmental impacts of this hog barn development. There were three key areas studied by the SCWMC - water, soil and air/odour.

Water monitoring has occurred annually from 2000 to 2010. Samples have been collected and analyzed from both surface and groundwater sources. The results of water quality monitoring of private wells was a valuable tool to increase the awareness among residents of the importance of protecting source water. The surface water sampling program has shown no measurable impact of the hog barns and manure spreading activities on area water quality.

Soil monitoring began in 2001 and is scheduled to end with the fall 2012 sampling event. The Five Year Report stated "At this point it is safe to say that manure application to the test fields has improved the fertility status of the soils while maintaining nutrient levels well within accepted environmental guidelines." Of note, since issuance of the Five Year Report, is the fact the manure application rate and timing of applications were adjusted based on the past years of soil sampling analyses. In most cases the adjustments that Big Sky made to its manure management plan have resulted in a better balance between manure application rates and crop removal of soil nitrates. Continued soil sampling to the fall of 2009 has shown the nutrient level of the soil continues to be within accepted environmental guidelines.
Odour monitoring took place from 2001 to 2004. The number and intensity of odour occurrences varied with the season, time of day, distance and direction from barns, weather conditions and the sensitivity of each individual observer. The highest odour rates occurred during May through October. Odour emissions were attributed to both the barn and the earthen manure storage (EMS) for each site.

The SCWMC members believe they have been successful in alleviating local fears and concerns about the hog barn development. Using a unique, transparent, unbiased approach and collaborating with contracted consulting services has given credibility to the Committee's studies and findings. The Committee has been accepted as a sounding board for concerns, and is seen as beneficial by many local residents.

REPORTS

Water

A sub-committee was established in the fall of 2000 to collect samples of both surface and ground water for analysis and to communicate the results to the public. The committee began by establishing a baseline for the water quality in dugouts, shallow wells and Spirit Creek before any hog barn development occurred in the area. Grab samples were collected and analyzed by the Saskatchewan Disease Control Laboratory. Refer to Table 1.

Table 1: Summary of Surface Water Quality Measurements 2001 – 2010

PARAMETERS	2001 - 2005			2006 - 2010		
	MIN	MAX	AVERAGE	MIN	MAX	AVERAGE
Conductivity (µS/cm)	149	1090	399	146	6440	619
pH (pH units)	7.1	8.9	7.5	7.4	8.1	7.8
Turbidity (N.T.U.)	0.64	34	5.9	0.75	172	17.1
Total Alkalinity (mg/l)	54	390	105	58	304	107
Bicarbonate (mg/l)	66	476	129	71	371	130
Total Hardness (mg/l)	41	589	176	39	469	243
Sodium (mg/l)	0	24	5.2	1	15	7.1
Magnesium (mg/l)	4	86	20	4	53	29
Calcium (mg/l)	8	104	37.0	9	102	50.1
Sulfate (ng/l)	2.2	270	81	4	333	149
Chloride (mg/l)	0	21.5	2.54	0.9	17.9	4.02
Potassium (mg/l)	2	42	18	7	29	16
Ammonia-Nitrogen (mg/l)	0	2.9	0.40	0.02	3.4	0.50
Nitrate-Nitrogen (mg/l)	0.66	10	2.8	0.1	21	1.9
Total Kjeldahl Nitrogen (mg/l)	1	6.4	2.5	0.73	3.6	1.7
Total Phosphorus (mg/l)	0.1	2.1	0.56	0.14	3.5	0.56
Ortho Phosphorus (mg/l)	0.04	1.9	0.43	0.08	3.4	0.45
Biochemical Oxygen Demand (mg/l)	1.1	19	6.0	0.92	23	6.3
Dissolved Organic Carbon (mg/l)	10	50	21	1.65	232	27.9

Groundwater sampling locations were chosen to monitor water chemistry within a three-mile radius of each of the hog barns. Samples were obtained from 11 private wells and 37 dugouts during the spring and fall of 2000. The number of samples increased in 2001 to 21 wells and 59 dugouts. In 2002 the sampling area was reduced to a two-mile radius with 10 wells and 25 dugouts tested. Well and dugout sampling ceased with the spring sampling event of 2004. This provided a very good representation of the water quality in the area, and succeeded in bringing the importance of water quality testing to the attention of local residents as many wells and dugouts, regardless of use (domestic, livestock, etc.), had never been tested for human consumption. Stream sampling points for surface water were selected at 19 locations throughout the upper watershed to provide information on water chemistry upstream, midstream and downstream of the hog barns and manure spreading activities. These sites were sampled annually during spring runoff and following a major rainfall event in 2005. The sampling program included data collected from the Rama and

Determining flow rate at station #4.

Buchanan reservoirs and Good Spirit Lake. Over 200 samples have been collected since the program began in 2000. Flow measurement at each water sampling station was initiated in 2008, thereby providing a better understanding of the potential downstream loading of nutrients. Analysis of the surface water quality from 2000 to 2010 shows a very high variability from year to year. Insufficient flow data has been collected (only 3 events – spring 2008, 2009 & 2010) to determine whether or not nutrient loading is an issue down stream. While the measured concentrations of nutrients, major ions and bacteria fluctuate between sampling events, no significant increasing or decreasing trend is observed. The water quality sampling at Good Spirit Lake shows similar fluctuations with the overall water quality considered good.

The analyses of surface water samples taken annually to the spring of 2010 continue to support the statement in Appendix E of the Five Year Report that states "The water quality parameters measured were observed to have typical concentrations for prairie streams".

Soil

Soil sampling began in 2001 to monitor nutrient levels in fields that receive pig manure as a crop production input. The monitoring began with a soil benchmark program followed by a manure and commercial fertilizer comparison program. The upper, mid and lower slopes of eight quarter sections are sampled regularly in 12 inch increments to a depth 48 inches. The soil sampling program will cease with the 2012 fall collection event.

The soil benchmark program found the fertility of the soils in the area to be relatively low. Subsequent annual sampling found an increase in nitrate in both manured and fertilized plots in all slope positions. The levels of nitrates were similar to levels seen in summer fallow fields in the province and were within current environmental guidelines.

Soil sampling - Keith Head (right) & Adam Kosar.

The sampling also found small increases in available phosphorus on manured plots and a decrease in available phosphorus in commercially fertilized plots.

Adjustments were made to the manure management and application plans as of 2006 resulting in slight changes to the timing and frequency of soil sampling. These adjustments created a better balance between the amount of nutrients applied and the nutrient uptake of the crop.

Air

A comprehensive study was conducted by the University of Saskatchewan to monitor the levels of hog barn odour that local residents would experience. The study area was within an 8 km radius of the three barns and involved 147 residences. All residents within the study area were given the opportunity to be trained and participate in the study. The study was conducted in two stages between 2001 and 2004. Stage one involved 50 residents. All were trained as odour observers to rate the intensity of odour in their area for one year. Stage two involved 32 residents who tracked the intensity of odour at least twice daily for one year. The second stage included two trained nasal rangers to monitor odour occurrences up to 6.4 km downwind of the barns at 105 separate locations. All data obtained from both stages showed a similar relationship of odour to factors such as wind speed

and weather conditions. Generally the lower the wind speed, the more frequent the reports of odour events and the higher the intensity of the reported odour. Most events were detected with wind speeds of or less than 5m/s (18 km/hour). The number and intensity of odour occurrences varied with the season, time of day, distance and direction from barns, weather conditions and the odour sensitivity of each individual observer. The highest odour detection frequencies and the highest odour intensity rates occurred during May through October. Odour emissions were attributed to both the barns and the earthen manure storage (EMS) for each site. Cover material (straw) on the EMS was effective in reducing odour emissions.

The odour monitoring project was completed and reported in Appendix F of the Five Year Report. Appendix F stated "Annual odour detection frequencies for twenty families ranged from 0.01% to 0.80%. Three families had higher odour frequencies of 1.19% (5.9 km), 1.51% (5.4 km), and 3.32% (2.8 km, near two other livestock farms)."

The Vaccine and Infectious Disease Organization with the University of Saskatchewan conducted an air quality project from April 2001 to August 2002. The objective of the study was to quantify the amount of airborne endotoxin and DNA downwind from a swine facility. The research project determined that air quality results were not significantly different 600 metres downwind of the barn than 2400 metres upwind ("fresh air") of the barn. The full report is available as Appendix B of the Five Year Report.

PUBLIC OPINION

Committee members polled several area residents. The following questions were presented:

- *Are you familiar with the Spirit Creek Watershed Monitoring committee?*
- *What items/activities do you feel the committee accomplished?*
- *Was the presence of the committee of benefit to you/ your neighbours?*
- *When you had a concern, did you contact the committee for assistance?*
- *Was the committee useful as a sounding board for your concerns?*

The questions were intended to gauge the benefit, if any, of the committee's activities over the last ten years. Responses were collected and are presented here as an indication of the committee's accomplishments towards achieving their mandate.

Responses:

"Yes, the committee monitors water and air quality from the Big Sky hog barns."

"The committee members were always eager to help and very professional."

"They were always very professional and eager to answer any questions I had. Just having a committee makes things more positive. I personally would like to see the committee to stay on and monitor any questions and or situations that may arise."

"The Spirit Creek Watershed Monitoring Committee did a good job in relieving any concerns that the community may have had about the intensive livestock in the area."

"Being a co-operator with the soil monitoring was beneficial in that we could see firsthand the potential of manure on the land. Thank you to the committee and Keith Head for the opportunity."

"We feel that the Spirit Creek Watershed Monitoring Committee in all those years of surveys, studies and monitoring of the entire Spirit Creek watershed area have informed the cottage owners, farmers, area residents and all people living in this watershed area by informing the public about the results and findings of the quality of the water in the Spirit Creek Watershed area."

"It was useless."

"My first concern was possible contamination of the shallow wells used for drinking. The committee did a great job in testing shallow wells used for drinking and monitoring for odour. The well from where I take water showed no signs of contamination. Job well done."

"The committee did a very good job towards serving the public's concerns. The testing of water in the wells was well done, and the monitoring of odour was also a benefit, no concerns."

Adam Kosar, a founding member of the SCWMC writes:

I am familiar with the SCWMC and have been a committee member since 2000. There were many concerns when the hog barns were first announced. Concerns for the residents and the committee members in regards to the effect this operation would have on our environment. At our committee meetings every concern was reviewed. (We monitored the water, soil and odour). It was a privilege to work with a committee and support staff of such high standards and with the residents who were so cooperative in participating in this study. This study has proven to me that there is room for intensive livestock operation in my community if properly managed with no damage to the environment.

Jim Davis, a founding member of the SCWMC writes:

I am very familiar with the monitoring committee as I served as a member from the formation of the committee until Oct 2004. I became a member to assist in monitoring the effect of the large Hog operations constructed in the Spirit Creek watershed. My home was at Good Spirit Lake so I had a vested interest in ensuring that my environment was kept safe.

The committee was and is involved in providing factual information on the effects of the large Hog raising complexes on Air, Water and soil quality in the area surrounding the barns and the Spirit Creek Drainage area.

This committee was the first of its kind in Canada and faced the daunting task of establishing a program for effective monitoring and public communication to establish a true picture of the environmental effects of this operation.

The committee participated in the development and implementation of programs to monitor Soil, Air and Water quality in the area. Public meetings were held and a News letter was published to counter anecdotal information which was being circulated by groups opposed to intensive livestock operations. The information gathered proved that this could be environmentally safe if guidelines by the Saskatchewan Ministry of Agriculture were followed.

This committee of concerned local citizens provided information to assess the effects of the Intensive Hog operation in our community. It assisted in monitoring adherence to government operating guidelines and allowed first hand involvement with Ministry of Agriculture employees who were tasked to ensure the Environmental safety of the Project. We participated in sampling ground water, soil analyses and air qualities and were given copies of all analysis.

Any questions about the environmental impact of the Hog operations in the Spirit Creek watershed were answered to my satisfaction. I can say that no adverse impact was found to ground water and soil contamination. Odour from the barns was a problem at times but improvements are ongoing.

Florian Possberg, a founding member of the SCWMC & former CEO of Big Sky Farms Inc., writes:

Big Sky Farms Inc. had permits for a 5000 sow farrow to finish project near Rama that started construction in 2000. Saskatchewan was developing many projects during this period. Pro and con debate was very passionate regarding large livestock projects. The project's large size combined with the special concerns centered around Good Spirit Lake resulted in the Saskatchewan Government forming the committee. As CEO of Big Sky Farms, I was asked to

participate. The hog industry touted our developments as environmentally responsible. SCWMC gave our project the opportunity to test our claims. I found the work done by SCWMC research was used to validate livestock operations regulations for Saskatchewan. Results were also used nationally and internationally.

Don Walters, founding chair of the SCWMC, writes:

In 1999 we learned about the development of the hog barns within the Spirit Creek Watershed. We felt that this development could have serious repercussions on the water quality of Good Spirit Lake. A proposed 125,000 hogs per year, housed in several hog barns would be located in the reaches of Good Spirit Lake. I, and others, were concerned about our drinking water and the quality of the lake water as well.
In response to our concerns with the Big Sky Farms/ Rama Hog Ventures, then Minister of Agriculture and Food, Clay Serby, formed the SCWMC. Our mandate was to monitor and report on possible water quality impact (if any) and to better understand water, soil, air quality issues in the watershed and to recommend practical, locally acceptable solutions.

I thought then and still do believe that the environment is the most important part in considering our future. We must work together. Working together is the only way we can achieve this success. Our committee feels that we were instrumental in keeping the environment and economy in the R.M. of Invermay growing. We all learned a lot.

I would like to thank all members of the SCWMC and support staff for a job well done. We all worked with a great deal of open mindedness and indeed a complete model of cooperation by all. We must not forget the residents of Rama, and the rural area surrounding the three hog barn sites, that participated in our research. Without their support there would not have been a successful report or no report at all.

CONCLUSIONS

The SCWMC continues to direct and communicate the monitoring of intensive hog development to ensure the sustainability of the environment in the Spirit Creek Watershed. Members worked diligently developing and administering monitoring programs in the area and communicating the results to residents. The Committee members remain members of the community and continue to have a vested interest in ensuring the environmental sustainability of intensive livestock development in the area.

Over the past ten years, the SCWMC, consultants and resource staff have collected data and analyzed the environmental impacts of the intensive livestock development on the watershed's air, soil and water resources. Data collected before and after development occurred was invaluable, and filled informational gaps that were and continue to be under great public scrutiny. The committee has determined no measurable change in surface water quality and groundwater quality is attributable to the presence of the hog barns and the associated manure spreading operations.

The Soil Monitoring project has shown increased soil fertility and enhanced crop yields are sustainably possible with the application of manure. Based on the soil monitoring program, initial application rates of manure were refined to achieve a better balanced uptake of the nutrients by the crop. Although no environmental impacts have been determined, proper management of the manure (and all crop nutrients) is a necessary annual decision item of the land owner to ensure nutrients are not applied in excess of the carrying capacity of the soil/crop system.

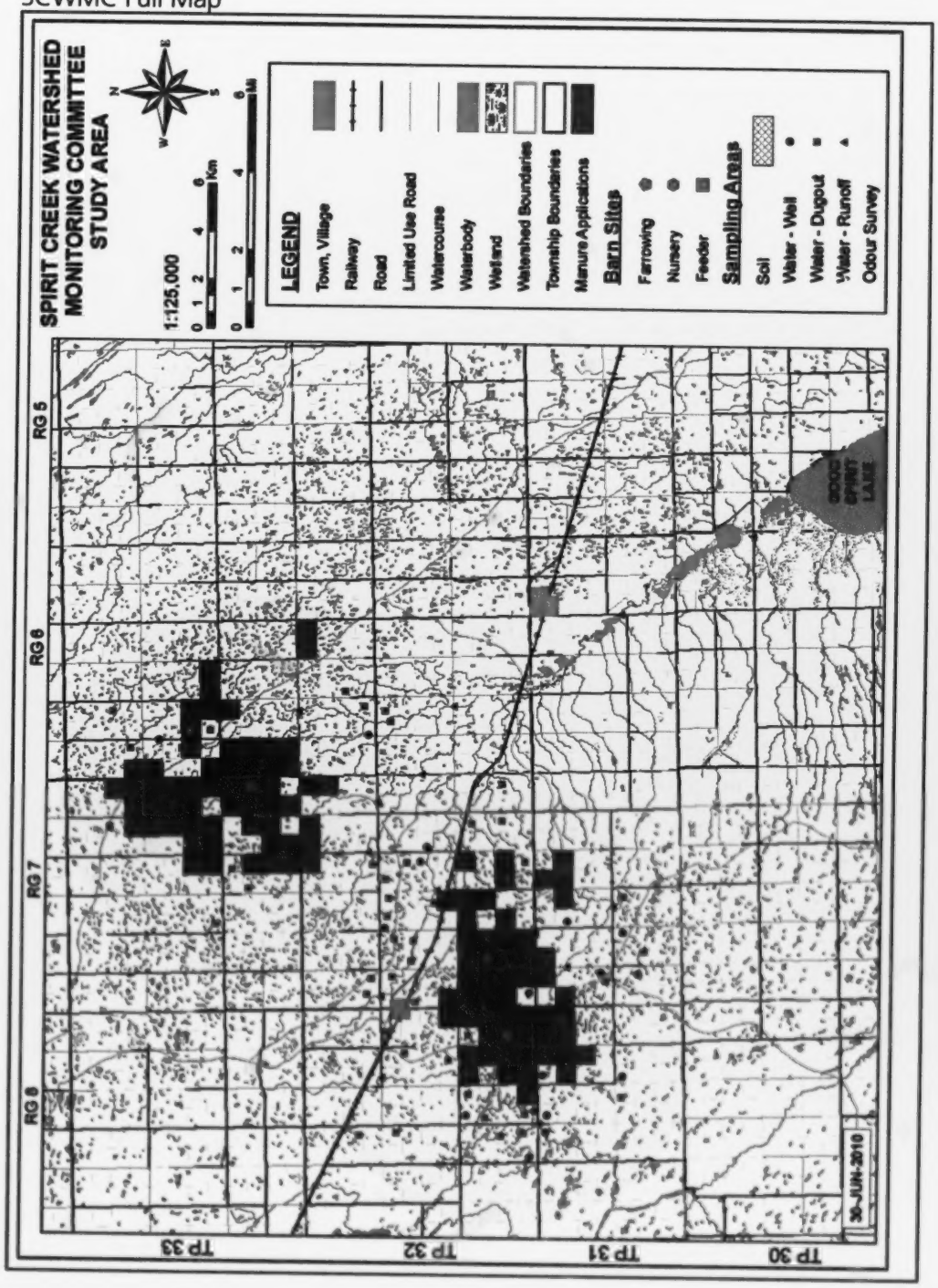
While some members of the community originally opposed to the development continue to be opposed, generally speaking the SCWMC was able to alleviate local fears and concerns about the hog barn development. This was achieved by maintaining a visible presence in the community and by involving

and informing local residents of the monitoring activities and results. Committee members provided a reliable and local contact for receiving and responding to residents' concerns. The SCWMC was established as one of the first of its kind. The unique approach taken by all those involved was vital to the Committee's success over the past 10 years.

Over the last ten years the SCWMC believes it has fulfilled the primary mandate of determining whether the presence of large hog facilities impact water, soil and air quality of the surrounding area.

APPENDIX G

SCWMC Full Map



APPENDIX H

SOIL/MANURE MONITORING PROGRAM

Head & Associates Ltd.

February 2011

INTRODUCTION

The Soil/Manure Monitoring Program was designed to monitor soils on which liquid pig manure is used as a crop production input.

The Program included three main areas of activity, the Initial Soil Benchmark Program, the Manure/ Commercial Fertilizer Comparison Program, and the Yearly Soil Monitoring Program.

The Soil/Manure Monitoring Program was initiated in 2001and completed in 2005. In 2006 the Yearly Soil Monitoring activities were extended for a further seven years to collect more information on the sustainability of the Big Sky manure management system.

Details and the complete results of the Programs are available at www.spiritcreek.ca.

The Initial Soil Benchmark Program

Fields considered representative of the area in the vicinity of the Big Sky Rama pig barns were sampled to establish nutrient levels in the soils prior to the first manure application. This established the baseline soil nutrient and chemical properties against which comparison could be made after manure has been applied to the fields.

Eight quarter sections were soil sampled on 12 inch depth increments to a depth of 48 inches. The upper, mid, and lower slope positions were sampled separately in each field. The soil nutrient and chemical properties (Table 1) were determined for each slope position in each of the fields.

Each soil sampling site was geo-referenced so that future sampling could be done at the same locations.

The results of the Soil Benchmark Program indicate that the fertility status of the soils of the area is relatively low. The initial available nitrogen levels to a depth of 48 inches, if two unusually high lower slope readings are excluded, averaged only about 52 lb/ac. The initial available nitrogen to 24 inches

was only 33 lb/ac, a level considered very deficient by soil test guidelines.

The available phosphorus levels, if three unusually high lower slope readings are excluded, averaged only 30 lb/ac. This phosphorus level is considered deficient by soil test standards and would generate a recommendation to apply from 30 to 40 lb/ac of phosphate.

The average available potassium level was about 528 lb/ac, a level considered sufficient by soil test guidelines. The available sulfur and micronutrient contents were all at levels considered sufficient for the annual crops produced in the region.

Table 1. Soil analyses for each soil depth layer

Depth (in)	Analyses
0 - 12	Available N, P, K, S, Cu, Fe, Zn, Mn, B, Total P, Organic Matter (OM), Electrical Conductivity (EC)
12 – 24	Available N, S, Total P, EC
24 - 36	Available N, S, EC
36 - 48	Available N, S, EC

The Manure/Fertilzer Comparison Program

The Manure/Fertilizer Comparison Program compared the efficacy of manure and commercial fertilizer as nutrient sources for crop production.

Four of the Soil Benchmark fields were divided into two areas. One area in each field was fertilized with commercial fertilizer and the balance of each field was fertilized with hog manure.

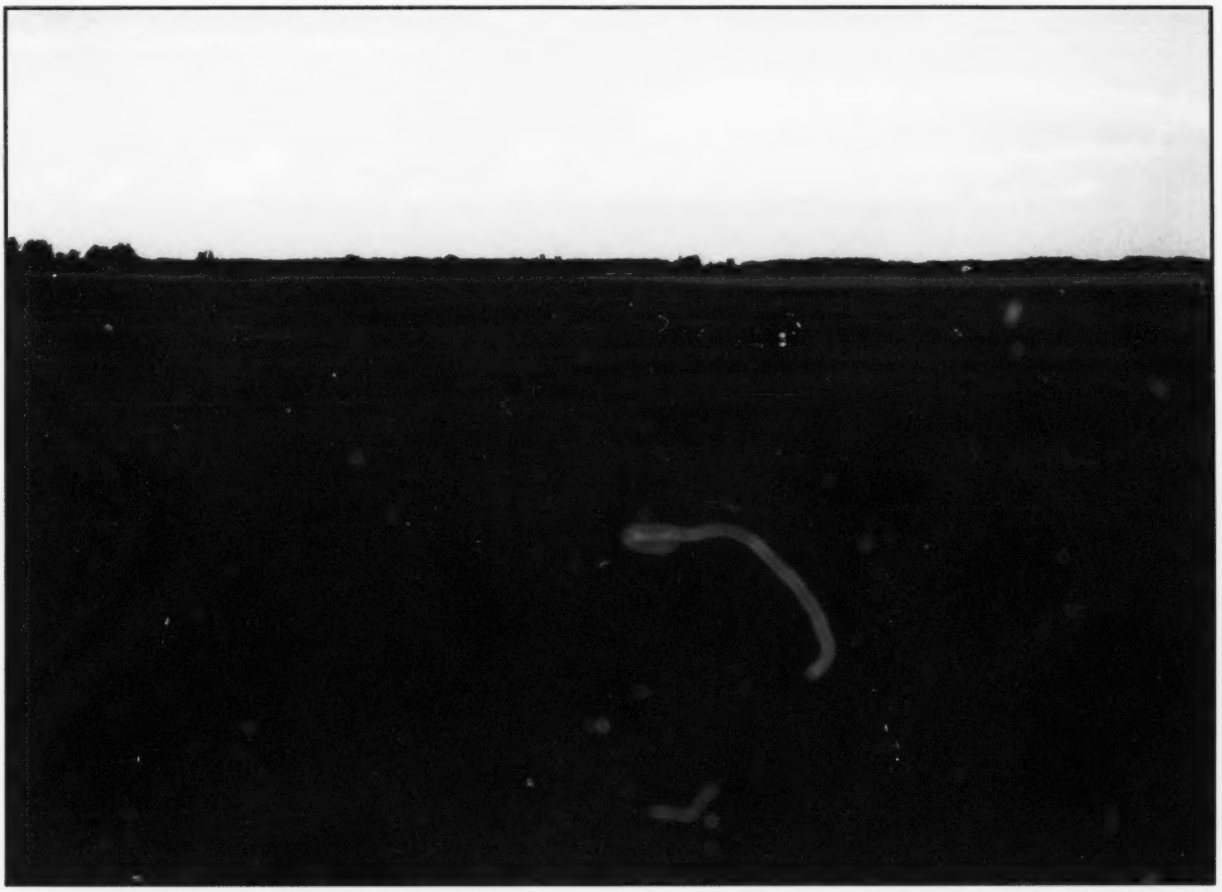
Crop yield and quality were determined for the first three crops following the initial manure application to the fields (See table 2).

Table 2. Yield and quality of crops on the Manure and Commercial Fertilizer plots

Year	Field	Plot	Crop	Yield (bus/ac)	Grade	Bus Wt (lb)	Protein (%)
2003	1	Manure	Barley	82	1CW	50.3	13.8
		Fertilizer	Barley	52	1CW	53.7	13.2
	2	Manure	Canola	32	1CR		
		Fertilizer	Canola	24	1CR		
	3	Manure	Wheat	50	1CWRS	63.1	15.3
		Fertilizer	Wheat	45	1CWRS	64.6	14.0
	4	Manure	Wheat	43	2CWRS	60.6	14.9
		Fertilizer	Wheat	41	2CWRS	60.4	14.3
2004	1	Manure	Canola	32	3CR		
		Fertilizer	Canola	22	2CR		
	2	Manure	Wheat	29	C Feed	59.4	13.9
		Fertilizer	Wheat	44	C Feed	62.7	12.5
	3	Manure	Barley	62	Sample	41.8	12.8
		Fertilizer	Barley	77	2CW	47.1	12.2
	4	Manure	Canola	22	1CR		
		Fertilizer	Canola	22	2CR		
2005	1	Manure	Wheat	37	3CWRS	61.7	11.5
		Fertilizer	Wheat	33	3CWRS	61.7	11.0
	2	Manure	Barley	52	Sample	47.2	13.0
		Fertilizer	Barley	46	2CW	44.3	12.1
	3	Manure	Canola	43	1CR		
		Fertilizer	Canola	36	1CR		
	4	Manure	Wheat	53	3CWRS	61.9	13.6
		Fertilizer	Wheat	47	3CWRS	61.9	12.4

In 2003 and 2005 crops produced with manure yielded more than those grown with commercial fertilizer (Figure 1). In 2004 however, two of the four Manure plots yielded less than the Fertilizer plots due to frost damage on the later maturing Manure plots.

Figure 1. Barley crop on Field 1 in 2003 with Commercial Fertilizer plot on left and Manure plot on right.



THE YEARLY SOIL MONITORING PROGRAM

The Yearly Soil Monitoring Program monitored the nutrient levels in each of the four fields in the Manure/ Commercial Fertilizer Comparison Program. Each year after harvest soil samples were collected from the same core sites as were used for the initial benchmark samples. Sampling was done to a 24 inch depth after the 2003 and 2004 crops to determine fertilizer requirements for the succeeding crops. In 2005, the final year of the study, sampling was done to the original 48 inch depth to determine any changes in the nutrient status of the field plots.

During the 3 crop years from 2003 to 2005 significant crop nutrients were added to the fields, both in the single manure application prior to the 2003 crop and in the form of commercial fertilizer added each year to the Manure plots as well as the Fertilizer plots (Table 3).

Table 3. Total crop nutrients applied to the field plots for the three crops from 2003 to 2005

Field	Plot	Total Nutrients Applied (lb/ac)			
		Total N	P	K	S
1	Manure	602	161	165	56
	Fertilizer	234	20	8	6
2	Manure	461	39	165	34
	Fertilizer	231	35	16	15
3	Manure	383	49	151	24
	Fertilizer	252	33	4	10
4	Manure	420	51	188	36
	Fertilizer	175	32	0	15

Soil Nitrogen

Soil nitrogen levels increased in both the Manure and Fertilizer plots during the course of the monitoring program. The increases occurred in all slope positions and averaged 85 lb/acre on the Manure plots and 38 lb/acre on the Fertilizer plots (Table 4).

The increase in nitrogen levels in the fields occurred in all soil layers to a depth of 48 inches (Table 5). The lowest increase was in the 0-12 inch layer and the highest in the 24-36 inch layer for both the Manure and Fertilizer plots.

Table 4. Average increase in soil nitrate-N levels (lb/ac) to a 48 inch depth in the Manure and Fertilizer plots between 2001 and 2005

Slope Position	Manure Plots Nitrate-N Levels (lb/ac)			Fertilizer Plots Nitrate-N Levels (lb/ac)		
	2001	2005	Increase	2001	2005	Increase
Upper	55	151	96	42	74	32
Mid	35	111	76	39	78	39
Lower	123	207	84	38	83	45
Average	71	156	85	40	78	38

Table 5. Average increase in soil nitrate-N levels (lb/ac) in the soil layers in the Manure and Fertilizer plots between 2001 and 2005

Soil Layer (inches)	Manure Plots Nitrate-N Levels (lb/ac)			Fertilizer Plots Nitrate-N Levels (lb/ac)		
	2001	2005	Increase	2001	2005	Increase
0-12	37	45	8	20	27	7
12-24	15	35	20	6	16	10
24-36	9	41	32	6	17	11
36-48	11	36	25	8	18	10
Total Average Increase			85	Total Average Increase		38

Soil Phosphorus

Soil phosphorus levels were quite low prior to the application of hog manure and, except for the lower slope positions, high rates of phosphorus fertilizer would have been recommended on the fields. The single manure application for the 2003 crop caused a modest increase in the levels of available soil phosphorus in the Manure plots (Table 6). The Fertilizer plots showed a decrease in available phosphorus in all slope positions, indicating that the levels of fertilizer phosphorus applied to the plots was not sufficient to maintain soil phosphorus levels during that particular cropping period.

Table 6. Average increase (decrease) in soil available phosphorus levels (lb/ac) in the Manure and Fertilizer plots between 2001 and 2005

Slope Position	Manure Plots Available Phosphorus Levels (lb/ac)			Fertilizer Plots Available Phosphorus Levels (lb/ac)		
	2001	2005	Increase	2001	2005	Increase
Upper	19	23	4	18	14	(4)
Mid	20	27	7	25	18	(7)
Lower	36	61	25	85	78	(7)
Average	25	37	12	43	37	(6)

Soil Potassium

The Manure plots received an average of 167 lb/ac of potassium from the manure and commercial fertilizer applications between 2001 and 2005. The levels of available potassium increased in the Manure plots by an average of 318 lb/ac. However, the Fertilizer plots also showed increases in available potassium although only receiving an average of 9 lb/ac of potassium, an amount that would have no significant impact on total soil available potassium.

It must be assumed therefore that a significant portion of the increase in soil available potassium observed in both Fertilizer plots and the Manure plots is due to factors other than the addition of potassium in the manure. These factors include mineralization of potassium due to the good moisture conditions in 2005, and variability in soil sampling.

Soil Sulfur
Sulfur levels have changed in the soils in both the Manure and the Fertilizer plots between 2001 and 2005. In the Manure plots the sulfur levels have increased an average of about 846 lb/ac. In the Fertilizer plots the sulfur levels have decreased an average of about 1850 lb/ac.

Neither of these changes can be attributed to manure or fertilizer application nor to crop uptake. The sulfur in the manure did not exceed 60 lb/ac on any of the plots so does not account for all of the increase in sulfur. Crop uptake on the Fertilizer plots does not account for the decrease in sulfur on those plots.

The observed changes in soil sulfur levels are likely due to differences in soil moisture and soil water movement, and perhaps most significantly, with variability in soil sampling procedures. The soils in the study area have sulfur levels of several thousand lb/ac. At these levels small differences in soil characteristics or sampling procedures can have large effects on soil analytical results.

Micronutrients
The levels of available micronutrients in the Manure plots increased between 2001 and 2005. However, the amount of increase was many times greater than the amount of micronutrients applied in the manure. On average the Manure plots received 0.28, 4.6, 0.5, and 1.7 lb/ac of copper, iron, manganese, and zinc, respectively. The levels of available micronutrients increased by 1.5, 54, 11.2, and 7.2 lb/ac for copper, iron, manganese, and zinc, respectively. The increase in the observed micronutrient levels must be due to factors such as soil and sampling variability rather than manure application.

The available micronutrient levels also increased in the Fertilizer plots, although no micronutrient fertilizers were applied during study, further suggesting that soil and sampling factors were affecting the analytical results.

ADDITIONAL SOIL MONITORING

In 2006 The Soil Monitoring Program was extended for an additional seven years to determine the effect of repeated manure applications on soil nutrient levels. During this time the eight original benchmark fields will be monitored for two more manure cycles. The additional monitoring will help evaluate the environmental sustainability of the manure management practices of Big Sky Farms.

The Soil Monitoring Program was designed to sample the fields on the basis of three crop years between manure applications. However, changes made by Big Sky to its manure management strategies to modify application rates and to accommodate changes in cropping plans of the recipient farmers have resulted in manure applications after as few as two to as many as five crop years. Consequently, the schedule of soil monitoring has needed to change as well. To date, four of the fields have been sampled a third time, and four a second time.

In most cases the additional sampling has shown that the adjustments that Big Sky has done to its manure management plan has resulted in a better balance between manure application rates and crop removal of soil nitrates. The soil nitrogen levels are summarized in Tables 7 to 14.

Table 7. Soil nitrate-N levels in the Manure and the Commercial Fertilizer plots in Field 1

Slope Position	Manure Plot				Commercial Fert Plot			
	Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth			Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth		
		2001	2005	2009		2001	2005	2009
Upper	1320	22	75	59	952	23	56	43
Mid	1320	26	94	88	952	23	54	36
Lower	1320	214	293	241	952	33	71	74

Table 8. Soil nitrate-N levels in the Manure and the Commercial Fertilizer plots in Field 2

Slope Position	Manure Plot				Commercial Fert Plot			
	Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth			Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth		
		2001	2005	2008		2001	2005	2008
Upper	835	28	139	35	605	28	72	51
Mid	835	37	113	58	605	27	69	39
Lower	835	211	380	248	605	34	95	69

Table 9. Soil nitrate-N levels in the Manure and the Commercial Fertilizer plots in Field 3

Slope Position	Manure Plot			Commercial Fert Plot		
	Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth		Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth	
		2001	2005		2001	2005
Upper	383	93	86	252	53	76
Mid	383	31	82	252	47	81
Lower	383	34	80	252	36	60

Table 10. Soil nitrate-N levels in the Manure and the Commercial Fertilizer plots in Field 4

Slope Position	Manure Plot				Commercial Fert Plot			
	Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth			Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth		
		2001	2005	2008		2001	2005	2008
Upper	703	76	306	103	458	64	90	71
Mid	703	44	155	78	458	61	106	45
Lower	703	33	75	52	458	50	105	91

Table 11. Soil nitrate-N levels in the manure area of Field 5

Slope Position	Manure Plot			
	Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth		
		2002	2006	2009
Upper	701	51	33	12
Mid	701	79	73	12
Lower	701	185	98	108

Table 12. Soil nitrate-N levels in the manure area of Field 6

Slope Position	Manure Plot		
	Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth	
		2002	2007
Upper	383	66	140
Mid	383	62	114
Lower	383	70	110

Table 13. Soil nitrate-N levels in the manure area of Field 7

Slope Position	Manure Plot		
	Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth	
		2003	2007
Upper	221	174*	81
Mid	221	199*	94
Lower	221	201*	101

*Manure was applied to Field 7 four days prior to sampling in 2003

Table 14. Soil nitrate-N levels in the manure area of Field 8

Slope Position	Manure Plot		
	Total N Applied (lb/ac)	Nitrate-N Levels (lb/ac) to 48 inch depth	
		2003	2008
Upper	388	51	34
Mid	388	32	37
Lower	388	124	107

SUMMARY

- Fields sampled in the Rama area around the Big Sky Farms pig barns had relatively low fertility levels prior to the addition of hog manure to the fields.
- Fields that received a single application of pig manure had higher yield potentials than fields that received only commercial fertilizer, primarily due to the high rates of plant nutrients applied with the manure than with the commercial fertilizer.
- Fields that received one application of pig manure and produced three crops after the application had a higher fertility status than fields that received only commercial fertilizer.
- While residual soil nitrate increased with one application of manure the levels were well within current environmental guidelines and were similar to levels commonly seen in summer fallow fields in Saskatchewan.
- The soil sampling of fields that have received a second manure application indicate that at the time of sampling the manure application rates of Big Sky Farms were well balanced with crop uptake of nitrogen.

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